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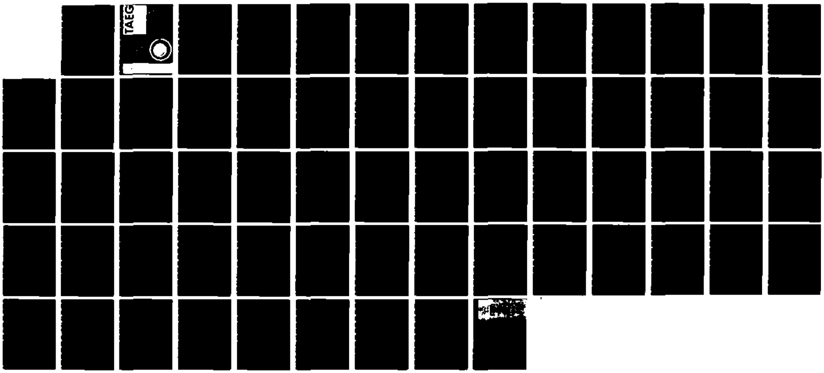

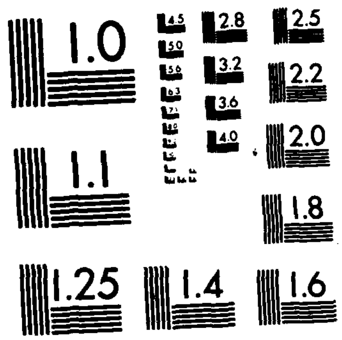

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TECHNICAL REPORT 152

AD-A134 718

DESIGN, DEVELOPMENT, IMPLEMENTATION, AND EVALUATION OF THE COMPUTER AIDED INTERACTIVE TESTING SYSTEM (CAITS)

AUGUST 1983

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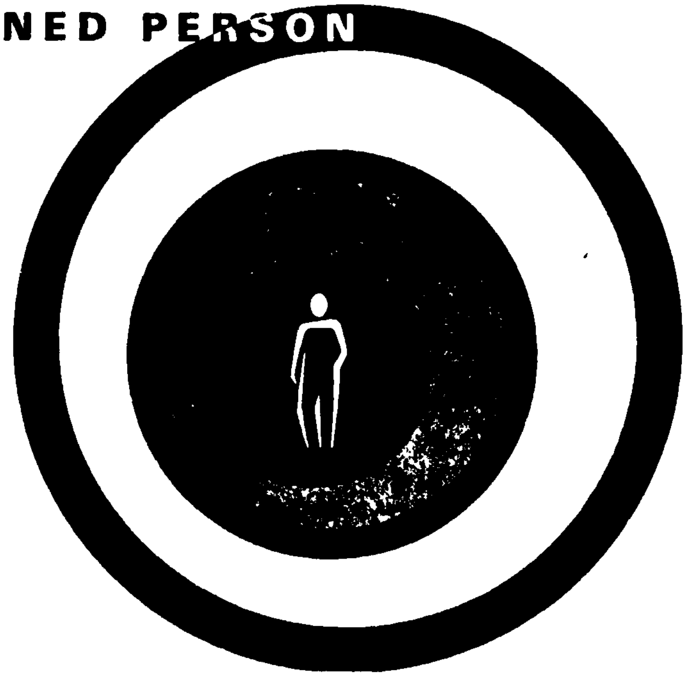

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TRAINING ANALYSIS AND EVALUATION GROUP
ORLANDO, FLORIDA 32813

Technical Report 152

DESIGN, DEVELOPMENT, IMPLEMENTATION, AND EVALUATION OF THE COMPUTER AIDED INTERACTIVE TESTING SYSTEM (CAITS)

Training Analysis and Evaluation Group

August 1983

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Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER Technical Report 152	2. GOVT ACCESSION NO. A134718	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) DESIGN, DEVELOPMENT, IMPLEMENTATION, AND EVALUATION OF THE COMPUTER AIDED INTERACTIVE TESTING SYSTEM (CAITS)		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER W1131
7. AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Training Analysis and Evaluation Group Department of the Navy Orlando, FL 32813		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE August 1983 13. NUMBER OF PAGES 60
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution is unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Computer Based Instruction (CBI)
Computer Managed Instruction (CMI)
Computer Aided Instruction (CAI)
Computer Aided Testing (CAT)
Economic Analysis
Training Effectiveness Evaluation
Training System Design

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Navy is looking for more effective and/or efficient means of managing instructional functions in the face of declining resources. Computer-based instruction is being carefully examined as an alternative to the more traditional ways of managing courses, managing student progress, testing, delivering instruction, and authoring courseware.

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20. ABSTRACT (continued)

This study describes one such alternative--the Computer Aided Interactive Testing System (CAITS). The design, development, implementation, and evaluation processes used for the CAITS are presented. also presented is an assessment of its general utility to the Naval Education and Training Command.

ACKNOWLEDGMENTS

This report documents the effort expended during each of the Computer Aided Interactive Testing System (CAITS) development phases. The material presented is a compilation of that provided by many contributors.

Mr. R. King and Mr. J. Carey of the Naval Education and Training Program Development Center, Detachment (NAVEDTRAPRODEVCENDET), Great Lakes, provided the initial management and instructional technology thrust to formalize the concept of CAITS into a new technology program. Dr. M. Zajkowski and Mr. C. Morris of the TAEG advised and assisted NAVEDTRAPRODEVCENDET, Great Lakes, developers during the conceptual system design phases and also developed the functional and system specifications. Mr. D. Kerkman developed the initial programs for the CAITS while under contract to the Navy. Mr. M. Duermyer of NAVEDTRAPRODEVCENDET, Great Lakes, served as the system and software design specialist responsible for all system integration. Mr. Duermyer also developed many of the programs used in the final CAITS configuration and is the point of contact at NAVEDTRAPRODEVCENDET, Great Lakes, for information pertaining to this system.

Dr. G. Micheli of TAEG directed the Training Effectiveness Evaluation phase of this study. The onsite evaluation plan was developed by Dr. W. Nordbrock of NAVEDTRAPRODEVCENDET, Great Lakes. This plan was later executed under the direction of both Dr. Nordbrock and Mr. Duermyer. The evaluation effort, which consisted of planning, data entry, data reduction and analysis was conducted by a TAEG team consisting of Dr. G. Micheli, Mr. L. Ford and Mr. T. Whitten.

The economic assessment of the system, which includes life-cycle costs and benefits for both the prototype system and potential follow-on systems, was conducted by Dr. W. Swope of TAEG. The conclusions and recommendations were prepared by a working group of all of the contributors mentioned above.

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*Published under separate cover. A copy may be obtained from the TAEG or NAVEDTRAPRODEVCENDET, Great Lakes.

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SECTION I

INTRODUCTION

Computer-Based Instruction (CBI) is receiving increasing attention as an alternative to the more traditional ways of managing courses, managing student progress, testing, delivering instruction, and authoring courseware. The objective of this ongoing development is to find more effective and/or efficient means of accomplishing instructional functions. This requirement is more compelling in view of declining resource availability for technical instruction. However, hypothesized efficiencies to be gained through the use of CBI in a variety of instructional contexts must be clearly demonstrated prior to operational commitment in view of the substantial economic considerations involved. This report describes one such demonstration. It documents the substantial effort expended in developing the logic and approach used in the design and subsequent implementation of the Computer Aided Interactive Testing System (CAITS) and addresses the applicability of the system in the Naval Education and Training Command (NAVEDTRACOM).

BACKGROUND

The CAITS is an automated testing system designed for use in group-paced instruction with remediation provided on line to students requiring it. It also contains an automated system for course and student management. The CAITS was originally conceived and proposed in 1980 by the Naval Education and Training Program Development Center Detachment (NAVEDTRAPRODEVCENDET), Great Lakes, for use in the Airman Apprentice Course at Naval Training Center, Great Lakes. The Chief of Naval Education and Training (CNET) Assistant Chief of Staff for Training System Management (N-9) authorized the development and pilot test of the system. The original plan called for in-house development, implementation, test and evaluation. Because NAVEDTRAPRODEVCENDET, Great Lakes, had many other development commitments during this period, and because of the scope of the proposed project, it became apparent that the CAITS program plan of action and milestones could not be met without additional resources. Subsequently, a meeting was held between representatives from the Training Analysis and Evaluation Group (TAEG) and the NAVEDTRAPRODEVCENDET, Great Lakes, to discuss the proposed development. During this meeting, it was suggested that TAEG provide support to NAVEDTRAPRODEVCENDET, Great Lakes, in the areas of system design, specification development, contracting, program monitoring and evaluation.

In coordination with CNET (N-9), the TAEG was tasked[1] to examine alternatives for accomplishing the proposed development. The alternative ultimately selected represented a mix of in-house and contract development with additional support provided by other Navy activities. The major development activity was collocated with the end user (schoolhouse) thus promoting greater efficiency in the development process.

The special circumstances surrounding this development, which allowed the use of personnel from a number of NAVEDTRACOM activities, each

[1]CNET ltr Code 022 of 6 Jan 1981.

contributing different and specialized skills, offered a unique opportunity to evaluate both this type of development effort and the specific CBI implementation for use in other training applications.

PURPOSE

This report describes the design, development, implementation, and evaluation of the CAITS. It documents the effectiveness/efficiency of CAITS and provides recommendations for decisions on employing this systems approach in a variety of Navy instructional contexts.

ORGANIZATION OF THE REPORT

In addition to this introduction, the report contains four sections and three appendices. Section II describes the various aspects of program management and coordination used to develop the CAITS. It also summarizes the system design approach which guided all subsequent development activities. Section III describes the design of the training effectiveness evaluation conducted on CAITS in the Airman Apprentice course at Great Lakes and presents the analysis of data collected. Section IV discusses the economic feasibility of the CAITS and provides information and data to support decisions dealing with the use of CAITS for other Navy training applications. Section V presents the conclusions and recommendations. Appendix A presents the alternative means considered for accomplishing CAITS development. Appendix B is the CAITS functional specification, and appendix C is the CAITS design specification. A supplement to this report contains the source listings for all CAITS programs. The listing is available from the TAEG or the NAVEDTRAPRODEVCEN, Great Lakes.

SECTION II

PROGRAM MANAGEMENT AND SYSTEM DESIGN

This section describes the various aspects of program management and coordination used for the development of the CAITS. It documents the relatively unique combination of in-house resources used to accomplish the objectives of the CAITS program. In addition, it summarizes the system design approach which guided all subsequent activities of the development.

PROGRAM MANAGEMENT

Figure 1 depicts the interorganizational structure used to suppc [illegible] che CAITS development. The following paragraphs elaborate on the various [illegible] ents depicted in figure 1.

The concept for development of the CAITS was originally propo [illegible] y education specialists at the NAVEDTRAPRODEVCENDET, Great Lakes. [illegible] as sponsored by the CNET Assistant Chief of Staff for Training System Management and technically supported by the TAEG. This development strategy allowed instructional systems development and computer program development to occur at a site collocated with the using activity at Great Lakes while allowing the system specification development, program coordination, and effectiveness evaluation functions to be accomplished by TAEG.

Early in the CAITS development program, the NAVEDTRAPRODEVCENDET, Great Lakes, Program Manager for Airman Apprentice training met with CNET staff and TAEG personnel to suggest a development strategy for the CAITS which would allow for a significant level of system development prerogative at Great Lakes without compromising design goals. It was proposed that TAEG personnel assist Great Lakes development personnel in finalizing a CAITS design and then support the development and evaluation effort. The approach outlined above allowed programs developed under contract to be integrated with those developed in-house without excessive delays normally caused by travel and coordination requirements. The onsite development approach also enabled close coordination between the instructional system designers and the computer program designers. This has proven to be a very important factor in the development process. Subsequent to these early planning and management decisions, TAEG was tasked by CNET to examine alternatives for accomplishing CAITS development. TAEG representatives met with NAVEDTRAPRODEVCENDET, Great Lakes, staff members at Great Lakes during February 1981 to discuss conceptual alternatives to satisfy CAITS objectives. During this working group meeting, a conceptual system design was developed. This design proposed the use of an Ohio Scientific classroom management microcomputer networked to 16 Bell and Howell student station microcomputers. Although there have been a number of minor hardware and software configuration changes since the conceptual design phase, the currently installed system closely reflects the original design. This initial working group system design was then used as a baseline by TAEG personnel to evaluate development alternatives for the implementation of the CAITS. The three development alternatives considered viable for the time and resource constraints imposed included (1) total development under contract, (2) total in-house development, and (3) a mix of in-house

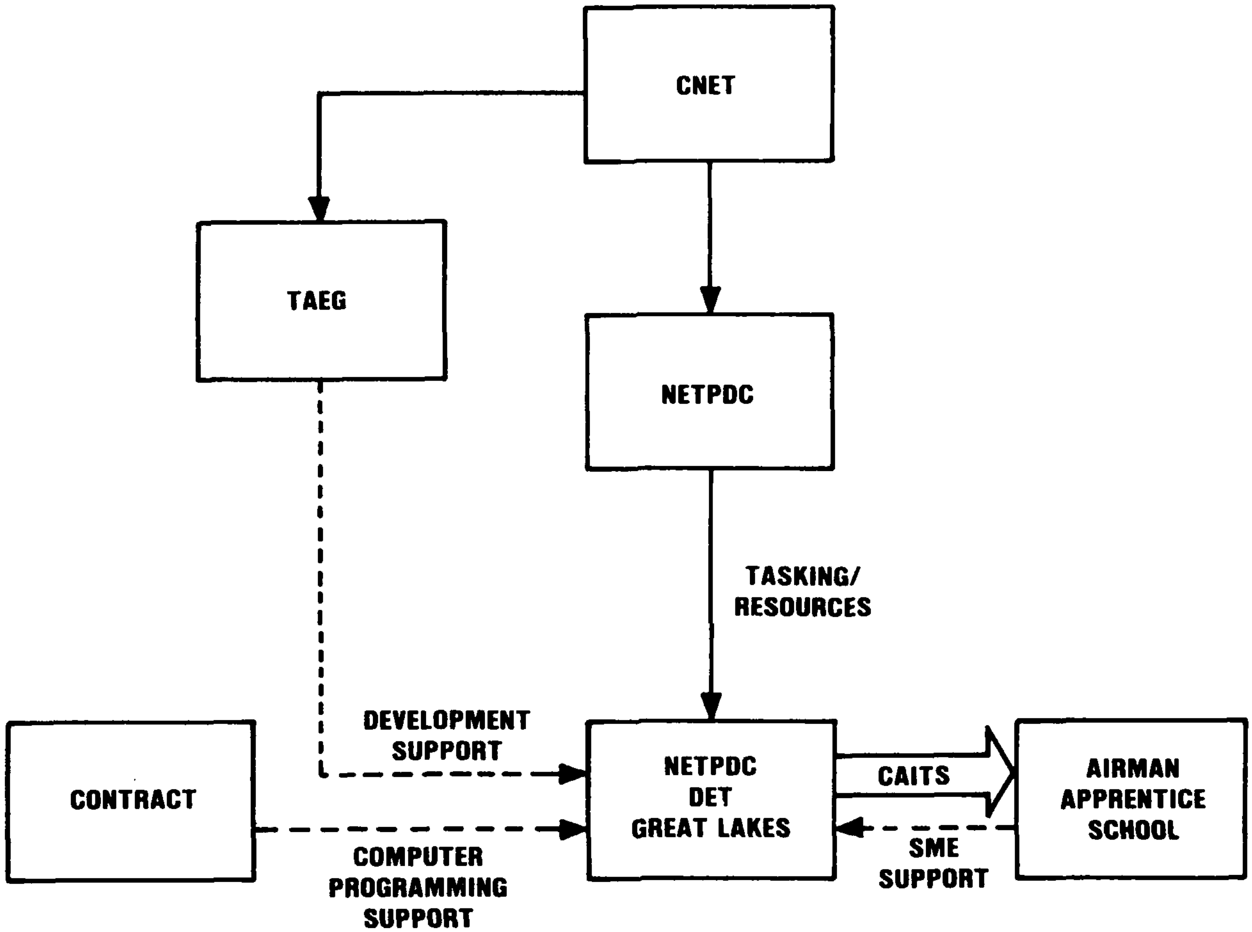

Figure 1. CAITS Development Organizational Support Structure

development and contract development. This development alternative assessment was submitted to CNET for consideration on 19 February 1981 and is included in this report as appendix A.

After reviewing the development alternative assessment, CNET tasked TAEG and NAVEDTRAPRODEVCENDET, Great Lakes, to initiate development for alternative 3 (a mix of in-house and contractor effort). Under this development option, TAEG was to prepare a statement of work and a contract package for computer program development, develop a system functional specification, develop a hardware and software system design specification, conduct periodic development progress reviews, perform a system effectiveness evaluation upon implementation, and, finally, conduct an economic evaluation for system cost-benefit assessment. The NAVEDTRAPRODEVCENDET, Great Lakes, was concurrently tasked to procure the necessary microcomputer equipment, perform the instructional system design functions, develop complementary microcomputer programs in conjunction with those developed under contract, perform the software/hardware integration, arrange for the required facilities changes, install the CAITS, and carry out all system implementation tasks. During this period, NAVEDTRAPRODEVCENDET, Great Lakes, established a New Technology Integration Office. The establishment of this office at the Instructional Program Development Center, Great Lakes, proved to be very beneficial during the CAITS development process. It provided dedicated resources in many of the new technology areas for which policy and procedures were not yet available. This organizational function should be considered for other Instructional Program Development organizations where new technology applications are being considered.

The TAEG prepared program planning documents in coordination with NAVEDTRAPRODEVCENDET, Great Lakes, to provide a basis for scheduling and progress assessment during program development. The system design phase consisted of design concept development, specification development, and system design review. Upon coordination and approval of the functional specification and the hardware/software specification, the computer program design effort was initiated and purchase orders were released for the computer hardware components. At each phase of the program design, such as the development of the program performance specification and program design specification, reviews were conducted to verify design adequacy. A similar verification approach was used at NAVEDTRAPRODEVCENDET, Great Lakes, for the development of the testing materials to be entered into the CAITS. By following this modular development approach and by testing program modules as they were completed, problems were identified and corrected as they developed. This resulted in a minimum of change during the final system hardware/software integration phase. The courseware and computer software development process was carried out in accordance with plan and, except for delays caused by programs with higher priorities, software/hardware integration was accomplished on schedule. It should be noted that the success of the design effort relating to courseware, computer software, and integration was due in large part to the expertise of NAVEDTRAPRODEVCENDET, Great Lakes, personnel and to the competency of contractor personnel (University of Central Florida Contract No. 61339-809-D-0014). Using TAEG as a technical support agent and NAVEDTRAPRODEVCENDET, Great Lakes, as the primary agent for development, CNET (N-9) was able to maintain management

control without becoming involved in the technical detail of design and development. This arrangement also allowed NAVEDTRAPRODEVCENDET, Great Lakes, to maintain responsibility for system design and development while having access to specialized micro-computer and subject matter experts from other Navy training organizations.

The use of microcomputers in the program was considered by CNET and NAVEDTRAPRODEVCENDET, Great Lakes, to be an innovative application of computers to test students and provide limited instruction in the form of remediation. Because CAITS represents a relatively new form of media within the NAVEDTRACOM, it was necessary to develop procurement, management, development, and operations methods to allow the integration of this media form into an ongoing instructional program without the administrative delays characteristically associated with larger scale procurements.

SYSTEMS DESIGN

This subsection elaborates on the system design phase of the program. The material is presented in detail since system design was the controlling factor in all other aspects of the development.

The major phases of the system design effort were (1) design concept development, (2) training system functional specification development, (3) system hardware/software specification development, and (4) predevelopment training system design review. Each of these phases is described in detail in the following paragraphs.

DESIGN CONCEPT DEVELOPMENT. Although the design concept for the CAITS had been outlined prior to the formation of the design and development team, it had not been subjected to an in-depth review. Consequently, a number of system configuration changes occurred during the design concept development process. The method used to arrive at a preliminary system concept was to hold a 3-day meeting at the Great Lakes Program Development Center with instructional system design specialists, computer system design specialists, and subject matter experts in attendance. During this meeting, the original CAITS concept was reviewed. This concept called for the development of an automated testing and remediation system for the 4-week course of instruction at the Airman Apprentice School. Some of the benefits to be realized from a system such as this were envisioned to be:

1. Improved test security through the elimination of hard copies, randomization of test item sequencing and response choices, the use of test access codes, and secured test authoring stations.

2. Improved student feedback through immediate analysis of student response and instantaneous selection of remedial loops or follow-on test sequences.

3. Decreased testing and remediation time through immediate response diagnosis and remediation selection.

4. Improved test scoring, student monitoring and data collection techniques through the automation capabilities of the computer.

5. More effective evaluation procedures for test item analysis and for the development of test validity, reliability and discrimination measures.

6. Suitability for performance-based testing through graphic display, simulations, and job related scenario displays.

7. Stand-alone testing stations and remote testing stations with around-the-clock availability for testing.

8. Automated test data collection and reduction with expansion capability for automatically communicating student status information to higher command levels.

9. Rapid authoring and update of test items without a requirement for printing updated versions of the test.

Other potential benefits such as shipboard training, enhanced mobilization capability and adaptability to many other ratings were also considered. The task of the system design group was to develop a design concept which would lead to the realization of the benefits envisioned. During the iterative development of the design concept, the system functional characteristics were specified and a number of hardware and software system alternatives were analyzed. Each alternative was assessed in terms of responsiveness to requirements, practicality, reliability, supportability and cost. In light of these constraining considerations, three configurations were selected as being viable. One configuration specified stand-alone student testing stations. A second configuration called for a central computer networked to testing terminals. The third configuration, which was the alternative initially selected, is based on a microcomputer management console controlling intelligent student testing stations. This configuration allowed for stand-alone operation if required but provided many of the benefits of a networked configuration such as single node system control, automated test response data collection and student station monitoring.

It was later decided to configure the first installation with stand-alone student stations. This approach allowed for evaluating the testing center concept before adding the complexity of networking. By agreement of the working group, TAEG was to develop functional and system design specifications to document the design concept. It was also decided that TAEG would include related system requirements such as operating systems, data communications, language options, modular testing of programs, documentation and evaluation. The development of functional and system specifications is discussed below. The actual specifications which guided the development of CAITS are included as appendices B and C.

FUNCTIONAL SPECIFICATION DEVELOPMENT. The functional specification describes the performance characteristics incorporated into the design of

the CAITS. It includes the major categories of (1) Administrative Subsystem, (2) Test Construction and Analysis, and (3) Test Delivery. Although the CAITS is designed as a testing system, it has inherent capabilities to be used as a computer-aided instruction (CAI) system, computer-managed instruction (CMI) system, or instructional administration system. The CAI capability is necessary to deliver remediation which incorporates text and graphics. The CMI capability was necessary to provide prescriptive feedback to the student on either the computer display or hard-copy printout. The administrative subsystem is required as an extension of the testing system and is used to prepare class rosters, testing schedules, student progress reports, and test response summaries. To assure that these capabilities would be included in the CAITS design, it was necessary to prepare a system functional specification to describe system characteristics in detail and to serve as a design baseline.

The administrative subsystem provides the functional capability to register students, update student records, prepare student progress reports, generate class rosters and automate other related administrative transactions. The student test data contain information by student and by class on test identification, scoring, items passed/failed, time on item, time on test, content areas passed/failed and remediation delivered. In addition to the test statistics collected, the administrative subsystem is designed to identify an individual's curriculum track and to provide editing features for changing entries if required. The information formatting is also structured to ensure compatibility with related CNET training management systems such as CMI and the Military Personnel Information System (MILPERSIS).

The testing method selected for CAITS is based upon the use of multiple choice tests with up to 50 test items on each test. These tests are subdivided into content areas in which the instructional designers can set the criteria for pass/fail by content area and by test. At the completion of test delivery, the student is remediated for each content area failed and then retested with alternate test forms in each of the content areas. If the student does not pass a content area after remediation, a prescriptive assignment is printed out for off-line review before re-entering the training system. All of these testing system functions are included in the functional specification in accordance with the CAITS design concept.

The functional description of the test construction and analysis capability includes such characteristics as test item banks, test item formats, item distractor randomization and comprehensive course level test generation. It also includes a capability for item analysis for each test by class and by school. This capability provides for statistical treatment relating to the analysis of item and test difficulty, discriminability, reliability, and validity.

The functional requirements for the test delivery system address micro-computer hardware and software capabilities which in turn must satisfy total system functional requirements. For the pilot implementation, it was required that 16 students be accommodated at one sitting and that each be provided with a terminal consisting of keyboard, display, and necessary

curricular materials. It was also required that test security and protection features be built into the system and that a hard-copy backup system be maintained to assure a testing capability under any adverse condition which might occur. In addition, the functional design provides for future expansion of testing capabilities, such as the addition of constructed response features. As a final functional requirement, it was specified that student stations be capable of operating in remote stand-alone configuration or in an integrated network mode with other host computers. The functional specification which contains the requirements described herein is included as appendix B.

HARDWARE AND SOFTWARE SPECIFICATION DEVELOPMENT. The TAEG initiated development of the system hardware and software specification upon completion of the system functional specification. This document specified computer hardware components, computer programs, system hardware/software integration, documentation requirements, and system test standards. Although the CAITS is primarily an in-house small scale development, it utilized relatively complex microcomputer hardware and software. Consequently, it was necessary to follow standard design and development procedures. In this system, a number of microcomputers are utilized as components of a classroom testing center in which computer programs and courseware are integrated to provide the needed operational capability. To reduce development risk, a number of microcomputer products were surveyed. Operating systems and languages were evaluated and special purpose hardware and software components were tested in house before making design decisions. The final configuration selected for the CAITS consisted of an Ohio Scientific microcomputer with a 10 megabyte hard disk to be utilized as a classroom management station. This was later changed to a Bell and Howell system to allow for interchangeability with student stations. This station was also to have a capability for authoring, evaluation, and administrative support. Initial designs, which were later rejected, included high speed parallel data transfer between the host and the student terminals to eliminate the requirement for floppy disks at the student station. This design approach was rejected because it did not allow for stand-alone student station operation. It should be mentioned, however, that follow-on configurations most likely will include high speed serial data interchange to provide data transmission to and from the host computer. A network configuration is also envisioned with 64 or 128K of RAM storage at each student station. A number of off-the-shelf local networking packages were also considered but were not included in the initial design because of cost and increased development risk.

A major issue during the survey was that of language selection. The candidate approaches included the use of Apple PILOT, UCSD PASCAL, compiled BASIC and standard interpreted BASIC. PILOT was rejected because of the desire to have complete development flexibility without having to configure student stations for a PASCAL-based language such as the Apple/Bell and Howell PILOT. PASCAL was rejected for similar reasons since a language card extension to the 48K Apple main memory would be required at each student station. A disk-based language also adds complexity, in comparison to the ROM-based applesoft BASIC interpreter, and was not considered desirable for

student stations. The compiled versions of BASIC were also rejected because of added complexity without any significant offsetting benefit. After considerable discussion, the design group developed an appreciation for the advantages of interpreted BASIC as a development language and better understood the reasons for its emergence as the leading personal computer language. It was selected as the development language for the CAITS and as of this time it is a decision which still appears to be supportable. BASIC is a relatively simple language, yet possesses the power needed for many applications of this type. If greater computational speed and/or language capabilities are required on future applications, such as simulation-based training, it is evident that other operating systems, languages, and hardware options will have to be considered. However, the design concept of not using more computational power than is reasonably needed continues to be one supported by the CAITS design group.

Documentation requirements for this development included a program performance specification, program design specification, program listings, test procedures and a user's manual. Although this limited amount of documentation would be considered minimal and possibly inadequate for a major training system development, it has proven to be more than adequate for the CAITS. Because BASIC program listings are easily understandable by qualified BASIC programmers, there have been no major problems in maintaining configuration control on CAITS programs. If good programming practices are followed, such as liberal use of remarks, minimal use of multi-statement lines, and modularization of programs, program update and maintenance can be easily and effectively accomplished. System test and evaluation were also addressed in the hardware/software specification and system tests were conducted prior to courseware integration.

SYSTEM DESIGN ENHANCEMENTS

During the CAITS development and preliminary testing phase, a number of potential enhancements were identified. These enhancements were necessary to correct deficiencies noted during schoolhouse validation of software. A progam update, which was accomplished at NAVEDTRAPRODEVCENDET, Great Lakes, to incorporate these enhancements, is identified as CAITS version 2.0. It is the current version of the CAITS software. The enhancements incorporated provide the following functional capabilities:

1. Allow students the ability to change answers while an item is displayed on the screen (however, maintain the restriction that once the student goes to the next item he/she cannot return to it to change answers).

2. Permit students the option of passing over an item to return to it later (when no answer is entered).

3. Display the total number of questions and the number of items remaining on the test at the bottom of each screen.

4. Plan for interruptions during the test to allow for re-entry at the point interrupted.

5. Allow for instructor specified remediation and retesting in a CAITS override mode.

6. Allow for latent remediation and retesting. With this capability students can return for remediation and retesting if authorized by the instructor.

7. Integrate manual testing methods with automated methods. Under version 2.0 testing can be accomplished with hard-copy tests and optically scanned answer sheets as well as by microcomputer. Testing under both methods can be concurrent and answer sheet data can be merged with floppy disk data for full CAITS management report generation.

8. Provide additional reporting enhancements including cumulative scoring, class summary statistics, student ranking, students remediated, class rosters, student transfers/drop list, and automated Academic Review Board (ARB) worksheets.

9. Provide a file editor program to allow for easy data entry, editing or update. With this feature, item banks can be reviewed and modified, if necessary, by school management. Student scores from classes which test with paper and pencil can also be merged with the computer generated data base for subsequent reporting and management purposes.

10. Provide randomization of test item sequencing and response choices.

All of these program features have been tested and validated and are currently being utilized for Airman Apprentice testing. The implementation of the total CAITS required only the installation of off-the-shelf microcomputer hardware and the integration with the CAITS program package as described herein. The expansion of this system or the installation of a system at another location would require only the addition of hardware and the integration with existing software. Only test item entry would be required for other testing applications. Since test item generation is necessary for testing in any mode, this effort would not normally be considered a cost for new applications. It is also probable that the efficiencies gained by having machine readable test item data in test data banks would result in lower overall cost for test generation and update. The hardware system as currently configured is shown in figure 2.

The software for this system is contained on the floppy disks in the form of an instructor disk, a student disk, and an authoring disk. The instructor disk contains the CAITS management programs and is menu driven. The student disk contains student test delivery and remediation programs. The authoring disk contains the programs needed to create and revise items and remedial data banks. Two complete tests with remediation can be stored on each side of a floppy disk for the Airman Apprentice Program.

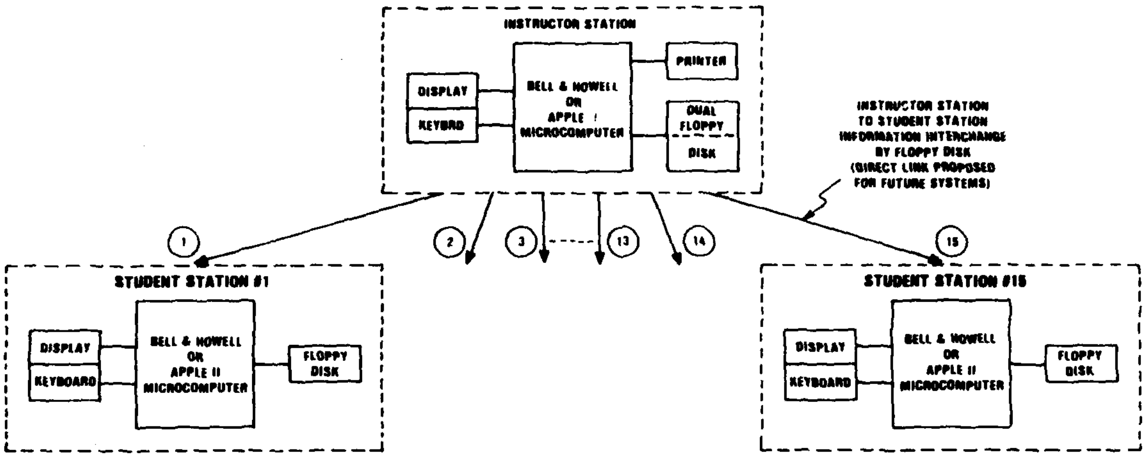

Figure 2. CAITS Hardware Configuration

SECTION III

TRAINING EFFECTIVENESS EVALUATION

This section describes the design of the training effectiveness evaluation (TEE) of CAITS in the Airman Apprentice course at Great Lakes and presents the analyses of data collected.

The TEE of CAITS addressed the:

- effect of the computer-presented versus traditional paper and pencil testings on the amount of time spent testing
- effect of computer tests versus paper and pencil tests on student performance (i.e., test results)
- effect on total testing time and student performance of remediation provided by CAITS compared to that traditionally provided by instructors.

AIRMAN APPRENTICE COURSE TESTING

The Airman Apprentice course is a 4-week, group-paced course which has been developed in conformance with the Instructional Systems Development procedures outlined in NAVEDTRA 110A and CNETINST 1550.15.

There are currently 10 end-of-module, criterion-referenced tests which occur following logically complete and related segments of instruction. These tests contain from 20 to 50 multiple choice items (over 90 percent of the items are multiple choice; the remainder are true-false and matching) which are administered to all students following the segment of instruction. The basic purpose of the tests is to determine whether or not each student has achieved the behavioral objectives which are the bases of the instructional material and test items.

DESCRIPTION OF TESTS, TEST SEQUENCE, AND REMEDIATION

The current Airman Apprentice course test items were used in this evaluation. They were the same for both computer presentation and for the traditional paper and pencil testing. For those items which require illustrations, a supplemental sheet of illustrations was provided to accompany the computer presentation of the items. A prompt appeared on the monitor directing the student's attention to the appropriate place on the supplemental sheet. (In the future, it will be possible to exploit the graphics capabilities of the computer.)

The sequence and frequency of testing conformed with that of the present Airman Apprentice course. The 10 testing points occurred following related, logically cohesive segments of instruction. Each such segment contained from one to four terminal objectives developed in accordance with the ISD model. Testing in the computer and paper-and-pencil modes occurred at the same points in the instructional sequence and covered the same terminal objectives.

Remediation procedures on CAITS differed from current procedures. Currently, remediation consists of the instructor reviewing frequently missed items directly following scoring of the test and "night study" for those students who did not meet criterion on the initial testing. "Night study" means that the student rereads all printed curricular material associated with the lesson, asks the instructor for clarification of any confusing area, and then retakes an alternate form of the end-of-module test. This remediation is a nonspecific "broad brush" approach which addresses sets of content areas associated with as many as four terminal objectives. Since the computer-based testing affords the opportunity for "on-line" remediation, it was decided to incorporate remediation based on more discrete, and thus more precise, diagnosis. Following each test administration, the computer evaluated the examinees' responses and provided a pass/fail report for the test. If a student did not attain the criterion cut-score, remediation was given immediately by CAITS. Following remediation, a retest was given, consisting of test items from the current alternate form of the test.

DATA ANALYSES

The data from this study were analyzed in three parts. Eight variables used in the analyses were:

- comprehensive test score (raw score)
- test scores (percent correct)
- Armed Forces Qualification Test (AFQT) score
- years of education (number of years)
- Reading score (Gates-MacGinitie Reading Test)
- Word Knowledge (subtest of the Armed Services Vocational Aptitude Battery)
- testing times (active time on the computer)
- group assignment.

In the first part, a multiple regression/correlation analysis was conducted on comprehensive test scores using various background information (AFQT score, years of education, reading score, word knowledge) and group assignment. This analysis was performed to examine possible differences in comprehensive test scores among three treatment groups while controlling for the possible effects of background variables. In the second part, the effects of remediation on test scores were assessed by t-test analyses. In the third part, averages were computed of testing times and remediation times for determining the duration of testing sessions. A description of the sample and the results from the three parts of analyses are described below. Questionnaires were administered to the two experimental groups that

were exposed, in part or in full, to the computer-presented treatment in order to identify student attitudes toward CAITS.

SAMPLE. The training effectiveness evaluation is based on a comparative analysis of three groups. Subjects in the study were randomly assigned to one of these groups:

- experimental group with on-line remediation
- experimental group with class review of the test
- control group.

The experimental group with remediation (n=92)[2] comprised those students who were tested on the computer and received remediation when their test scores on a content area fell below a specified criterion. Students in the experimental group without remediation (n=103) were also tested on the computer. However, regardless of their score on a content area, they were given class review of the test. The control group (n=101) was tested by paper-and-pencil tests and given class review.

DIFFERENCES AMONG TREATMENT GROUPS ON COMPREHENSIVE TEST SCORES. Multiple regression/correlation analysis was performed on the comprehensive test scores of all three groups to determine differences among the three treatment groups in comprehensive test scores while controlling for AFQT scores, years of education, reading score, word knowledge, and group assignment. Means and standard deviations for the variables used in this analysis are presented in table 1.

The two experimental group variables are analyzed in this regression model using the dummy variable technique.[3] This technique involves the creation of dummy variables that reflect group membership. In this case, since there are three groups, one control and two experimental, two dummy variables are required. One dummy variable is coded with a value of "1" if the student is a member of the first experimental group and "0" if he or she is not. The other dummy variable is coded "1" if the student is a member of the second experimental group, and "0" otherwise. If a student has "0s" on both dummy variables, then he or she must be a member of the control group. Thus, only two dummy variables are necessary to analyze the differences among three groups.

[2]Thirteen students assigned to the experimental group with remediation, for various reasons, aborted the testing sessions resulting in inconclusive remediation score data; therefore, analyses for determining the effects of remediation included only 79 students.

[3]For a more detailed explanation of the dummy variable technique, see J. Cohen and P. Cohen. Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1975.

TABLE 1. MEANS AND STANDARD DEVIATIONS FOR VARIABLES IN THE MULTIPLE REGRESSION/CORRELATION ANALYSIS

	Control Group			Experimental Group With On-Line Remediation			Experimental Group With Class Review of the Test		
	Mean	Standard Deviation	N	Mean	Standard Deviation	N	Mean	Standard Deviation	N
<u>Dependent Variable</u>:									
Comprehensive Test Score	81.7	6.8	85	83.0	6.3	68	83.1	6.2	95
<u>Independent Variables</u>:									
AFQT	54.0	19.0	101	53.1	19.7	84	53.0	19.5	102
Years of Education	11.5	1.1	101	11.8	0.8	84	11.6	1.1	102
Reading Score	10.9	1.9	101	10.7	2.0	84	10.9	1.9	100
Word Knowledge	53.1	6.3	101	51.7	6.1	84	52.6	6.3	101

Based on the results of the regression analysis reported in table 2, there are no significant differences among the three treatment groups in comprehensive test score, controlling for AFQT score, years of education, reading score, and word knowledge score. In fact, the two experimental groups scored slightly higher than the control group (table 1). Therefore, at the very least, the CAITS resulted in performance equivalent to that obtained with more traditional methods.

TABLE 2. MULTIPLE REGRESSION OF COMPREHENSIVE TEST SCORE ON TREATMENT GROUP, STANDARDIZED TEST SCORES, AND YEARS OF EDUCATION

Independent Variables	Regression Coefficient	t
Experimental Group 1	1.47	1.53
Experimental Group 2	1.51	1.72
AFQT	.06	2.20*
Years of Education	1.01	2.74*
Reading Score	.71	2.97*
Word Knowledge	.11	1.38

Note: R^2 = .20, F (6,239) = 9.66, $\underline{p}<.001$.
* indicates significant t-test with $\underline{p}<.05$.

EFFECTS OF REMEDIATION ON TEST SCORES. Ten tests comprised of 39 content areas were administered to the students. For those students within the experimental group with on-line remediation, each content area had a potential for remediation whenever the student's number of correct responses was lower than a specified criterion. Sixty-nine of the seventy-nine students within the experimental group with on-line remediation were remediated. The minimum number of remediations by a remediated student was one; the maximum was nine. For all the students who were remediated, an average of 3.57 remediations occurred. For the 246 occurrences of remediation, there were only 155 instances (63 percent) where the post-remediation test score was adequate for passing a particular content area.

To examine the effects of remediation, t-tests were performed on the mean content area pre- and post-remediation test difference scores and on the mean content area comprehensive test scores for which remediation was indicated.

For all the content areas in which remediation occurred, averages of the pre-remediation test scores and averages of the corresponding post-remediation test scores were computed to give average pre-remediation and average post-remediation test scores, respectively. To determine the immediate effects of remediation on test scores, the difference between the pre-and post-remediation test scores was tested for significant difference from zero. The results of the t-test showed a significant difference between the average pre- and post-remediation test scores ($t = 11.31$, $df = 68$). The average post-remediation test scores were higher (mean difference = 21.62), indicating that remediation did improve a student's test score in the short term.

To determine the long-term effects of remediation on test scores, the mean content area test scores and the mean content area comprehensive test scores were compared between those students who were remediated (n=69) and those students who would have received on-line remediation but did not because of being assigned to the experimental group with class review of the test (n=84). Mean content area test scores and mean content area comprehensive test scores were computed by averaging the test scores and the comprehensive test scores, respectively, for all the content areas where the number of correct responses was lower than the specified criterion. For the two groups, the results of the t-test showed that there were no significant differences in the mean content area test scores ($t = 0.44$, $df = 151$) or in the mean content area comprehensive test scores ($t = 0.18$, $df = 93$);[4] therefore, remediation did not have a significant long-term effect on improving a student's comprehensive test score.

DURATION OF TESTING SESSION. To determine the duration of the testing sessions, averages were computed of the testing times for each test for the two experimental groups that were tested by the computer. Table 3 presents the averages.

As can be observed from table 3, test #7 had the shortest average testing time, while test #6 had the longest average testing time. The average testing time considering all testing sessions was 28.51 minutes. This compares to 1 hour for each testing session for the control group.

In addition to the above testing time, students in the experimental group with on-line remediation also spend time in remediation. Therefore, for each test, averages were computed of the amount of time students were in remediation. These average remediation times are reported in table 4. The average time a student spends in remediation for any of the tests was less than 5 minutes.

[4]Content area comprehensive test scores were missing for 58 cases. Thus, t-tests were performed to determine bias between the two groups due to missing comprehensive test scores. No significant differences in average test scores were found.

TABLE 3. AVERAGE TESTING TIMES FOR EXPERIMENTAL GROUPS

	Mean	Standard Deviation	N
Test #1	30.83*	7.39	194
Test #2	24.55	5.83	191
Test #3	31.26	7.15	189
Test #4	22.37	5.41	189
Test #5	35.66	9.12	185
Test #6	38.44	9.00	180
Test #7	18.87	5.34	180
Test #8	21.72	5.76	177
Test #9	31.25	6.39	174
Test #10	30.18	6.19	173
Over All Tests	28.51	9.15	195

*Time is in minutes.

TABLE 4. MEAN REMEDIATION TIMES

	Mean	Standard Deviation	N
Test #1	4.83*	3.18	26
Test #2	3.29	1.99	25
Test #3	2.45	0.88	8
Test #4	4.76	2.64	10
Test #5	3.43	2.17	43
Test #6	3.87	3.88	7
Test #7	2.95	2.17	11
Test #8	3.57	2.19	26
Test #9	2.42	1.11	18
Test #10	1.96	1.86	9

*Time is in minutes.

STUDENT ATTITUDES TOWARDS CAITS. Questionnaires were administered to the two experimental groups which were exposed, in part or in full, to the computer presented treatment. The students were asked:

- How well do you think the tests tested your knowledge?
- Do you think the tests were difficult?
- What is your feeling about the way the tests were given?

Average responses to the above questions were computed for each class and over all the classes. Overall means and frequencies of responses are presented in table 5. Students thought the tests tested their knowledge fairly to very well, the tests ranged from slightly to somewhat difficult, and their feelings were neutral to positive about the way the tests were given.

TABLE 5. OVERALL MEANS AND FREQUENCIES OF STUDENT RESPONSES TO QUESTIONNAIRE

What is your feeling about the way the tests were given?		How well do you think the tests tested your knowledge?		Do you think the tests were difficult?	
(1)	Strongly dislike	(1)	Very poorly	(1)	Not at all difficult
(2)	Don't like	(2)	Poorly	(2)	Slightly difficult
(3)	Neutral	(3)	Fairly well	(3)	Somewhat difficult
(4)	Like	(4)	Very well	(4)	Very difficult
(5)	Strongly like	(5)	Extremely well	(5)	Extremely difficult
Frequency of Responses		Frequency of Responses		Frequency of Responses	
(1)	6	(1)	1	(1)	12
(2)	12	(2)	3	(2)	43
(3)	34	(3)	41	(3)	*78
(4)	*55	(4)	*73	(4)	4
(5)	29	(5)	19	(5)	Ø
Total:	136	Total:	137	Total:	137
Mean = 3.65 S.D.[1] = 1.050		Mean = 3.77 S.D. = .738		Mean = 2.54 S.D. = .697	

*Mode

[1]Standard Deviation.

SECTION IV

ECONOMIC ANALYSIS

This section discusses the economic feasibility of the CAITS and provides information and data to support decisions dealing with extending the use of CAITS to other Naval training applications. The analysis and cost data presented in this section are based on the following assumptions:

1. The planning period is limited to 7 years because it is assumed that improvements in microcomputer technology within this period will make current technology economically obsolete.

2. The salvage value of all hardware is estimated at 10 percent of the original purchase price.

3. The costs and benefits are discounted at a rate of 10 percent.

4. The costs are considered incremental.

5. Additional instructor and administrative support will be required to install additional CAIT systems.

6. Administrative and instructor support will be required to operate additional systems but because of a restructuring of the work load this support can be provided from resources already available and will not require new or additional resources.

7. The only additional resources required to operate the system on an annual basis will be for maintenance of equipment and supplies.

COST ANALYSIS

Since initiation of the CAITS program in 1980, there has been some improvement in the capability of microcomputers and a continuation of the downward trend in hardware prices. Consequently, the hardware costs experienced in acquiring the pilot system are no longer relevant for estimating the costs of additional hardware for expansion or for other applications. The following cost analysis is divided into three parts. The first part documents the actual costs of conducting the pilot program including both the hardware and development costs. The second part provides estimates of the costs for continuing to operate the 15 student station system developed for the pilot program. The third part provides an estimate of the life-cycle costs of expanding the CAITS. All costs are based on a CAITS consisting of 15 student testing stations and one instructor station with minimum equipment to serve as backup.

COST OF THE PILOT SYSTEM. Each student station includes one Apple II microcomputer, one single disk drive, and one monitor. The instructor station includes one Apple II microcomputer, two disk drives, a monitor, a printer, and a clock card. The total costs of purchasing and installing the hardware, developing the initial software and providing the in-house support for acquiring and installing the CAITS are presented in table 6. The total

TABLE 6. LIFE-CYCLE COSTS FOR THE COMPUTER AIDED INTERACTIVE TESTING CENTER ACQUIRED FOR THE PILOT STUDY*

RESOUPCE	TOTAL INVESTMENT COSTS Quantity	Unit	Unit Costs	Invest Costs	ANNUAL OPERATING COSTS 1	2	3	4	5	6	7	SALVAGE VALUE
Equipment												
Microcomputers	19	each	1500	27000								2700
Disk drives-w/int	19	each	450	8550								855
Clock cards	1	each	250	250								25
Monitors	18	each	395	7110								711
Printer with int	1	each	1100	1100								110
Maintenance					1000	1000	1000	1000	1000	1000	1000	
Subtotal				44010	1000	1000	1000	1000	1000	1000	1000	4401
Supplies					500	500	500	500	500	500	500	
Installation			1500	1500								
Labor												
Contracted	.33	man-yrs	54000	18000								
In-house	.5	man-yrs	30000	15000								
Admin, Sup, Trng	.5	man-yrs	20000	10000								
Total				88510	1500	1500	1500	1500	1500	1500	1500	4401
Net present value (94022)												

*Includes one instructor station and spare equipment.

one time investment costs amounted to $88,510. The estimated annual cost of operating the system after it has been developed and implemented is $500 per year for supplies (which are primarily disks and paper for printing student reports) and $1,000 for maintenance of the equipment. The net present cost of the pilot program is estimated at $94,022 for the 7-year period. Potential cost savings which might result from the elimination of the paper used for the present testing system are considered minimal and are not included.

RETENTION COST OF PILOT SYSTEM. The investment in the software and supporting hardware for the pilot system has been committed to the program and is in fact a sunk cost. Therefore, cost is irrevelant to the decision of whether it is economically feasible to continue with the pilot system in the operational environment. The current value of the resources invested in the system (i.e., the costs which are currently recoverable) is estimated at 50 percent of the hardware costs. The recoverable costs are estimated at $22,005. It is assumed that none of the investment in software and installation costs have an alternative value. The life-cycle cost (discounted at 10 percent) to continue the operation of the 15 student station system acquired for the pilot program is estimated at $28,595 or approximately $4,000 per year (table 7). However, the incremental operating costs estimated at $1,500 per year, are the only additional funds which must be provided to continue the operation of the pilot system.

TABLE 7. ESTIMATED LIFE-CYCLE COSTS OF CONTINUED UTILIZATION OF THE COMPUTER AIDED TESTING SYSTEM ACQUIRED IN PILOT PROGRAM

Resource	Current Equip Value	Year 1	2	3	4	5	6	7	Salvage Value
Equipment	22005								220.5
maintenance		1000	1000	1000	1000	1000	1000	1000	
Supplies		500	500	500	500	500	500	500	
Labor									
contracted		0	0	0	0	0	0	0	
in-house		0	0	0	0	0	0	0	
Total	22005	1500	1500	1500	1500	1500	1500	1500	220.5
Net present value (28,595)									

LIFE-CYCLE REPLICATION COSTS. Further expansion of the CAITS will be less expensive than the costs incurred for the establishment of the pilot system. Two factors contribute to the lower costs. First, the cost of developing the generic software need not be duplicated as additional systems are brought on-line. The cost of any generic software modifications necessary for expansion of the system are minimal or nonexistent. Second, there has been a decrease in the cost of microcomputer hardware since the hardware was acquired for the pilot program. The estimated life-cycle cost for each additional 15 student station testing system is presented in table 8. The estimated life-cycle cost (discounted at 10 percent) is estimated at $54,097 or approximately $7,700 per year. The initial investment costs are estimated at $48,100 with annual operating costs estimated at $1,500 per year. A summary of all three aspects of the cost analysis is presented in table 9. A CAITS-type testing system can be developed and implemented for other lock-step courses, but there would be additional resource requirements for the development of the test items and remediation modules which are relevant to the course. A unique economic analysis would be required to support decisions about specific applications.

BENEFITS

The CAITS has the capability to replace pencil and paper tests and provide immediate remediation to those students who require it. In addition, CAITS provides a capability for selective remediation with respect to course content. The current testing system requires a 1-hour testing period followed by a 1-hour block of time for review and remediation. Data from the CAITS pilot study show that those students who were remediated, with the computer, required an average of less than 5 minutes of selective remediation per test. Students were remediated only in content areas in which a performance deficiency was demonstrated.

The computer aided testing time per student per test was approximately one-half hour as reported in section III. The total estimated time, including remediation and overhead time, was estimated at .55 hour per test per student. The total estimated time savings over the testing, review and remediation time required for present methods was estimated at 1.45 hours per student per test. Table 10 summarizes the test and remediation times for both the CAITS and the conventional pencil and paper testing methods, assuming that one 15 student station testing center is used.

A 15 student station CAITS can accommodate 1,000 students per year. It is estimated that the acquisition and use of such a system could save 14,500 student training hours per year (table 11).

TABLE 8. LIFE-CYCLE COSTS FOR A 15 STUDENT STATION COMPUTER AIDED INTERACTIVE TESTING CENTER USING EQUIPMENT PRICES AS OF 1983*

	TOTAL INVESTMENT COSTS				ANNUAL OPERATING COSTS							
RESOURCE	Quantity	Unit	Unit Costs	Invest Costs	1	2	3	4	5	6	7	SALVAGE VALUE
Equipment												
Micro computers	18	each	1100	19800								1980
Disk drives-w/int	19	each	350	6650								665
Clock cards	1	each	250	250								25
Monitors	18	each	350	6300								630
Printer with int	1	each	1100	1100								110
Maintenance					1000	1000	1000	1000	1000	1000	1000	
Subtotal				34100	1000	1000	1000	1000	1000	1000	1000	3410
Supplies					500	500	500	500	500	500	500	
Installation			1500	1500								
Labor												
In-house	.25	man-yrs	30000	7500								
Admin, Sup, Trng	.25	man-yrs	20000	5000								
Total				48100	1500	1500	1500	1500	1500	1500	1500	3410
Net present value (94,022)												

*Includes one instructor station and spare equipment.

TABLE 9. SUMMARY TABLE OF COSTS OF IMPLEMENTING A 15 STUDENT STATION COMPUTER AIDED INTERACTIVE TESTING SYSTEM

Alternative	Life-Cycle Costs*		Annual Operating Costs
	Total	Average Annual	
Pilot System	$94,022	$13,432	$1,500
Retention of Pilot System	28,595**	4,085	1,500
System Replication	54,097	7,728	1,500

*Based on present value costs computed using a 10 percent discount rate.
**Excludes sunk costs.

TABLE 10. AVERAGE STUDENT TEST AND REMEDIATION TIME PER TEST FOR CAITS AND TRADITIONAL TESTING

Testing System	Testing Time	Posttest Remediation (Hours)	Total
CAITS	.55*	None	.55
Paper Tests	1.00	1.00	2.00
Time Reduction			1.45

* Includes remediation and overhead time.

TABLE 11. ESTIMATED POTENTIAL TIME SAVINGS PER YEAR FOR A 15 STUDENT STATION TEST CENTER WITH 1,000 STUDENT THROUGHPUT

Number Students	Tests Per Student	Time Reduction (Hours)		Total Time Savings
		Test	Student	
1,000	10	1.45	14.5	14,500

Approximately 2,000 students per year complete the Airman Apprentice course at Great Lakes. If the CAITS were expanded for that course so that all student testing could be done on the computer, then an estimated 29,000 testing hours could be eliminated from the instructional progam. However, an additional 15 student station system would be required to service the entire Airman Apprentice course. The estimated additional life-cycle cost of replicating a 15 student station system would be approximately $54,000 and when added to the rest of the pilot system increases the total system cost to $158,000. The cost of providing instruction in the Airman Apprentice course is estimated at $11.50 per hour; the potential annual cost savings which could be realized are summarized in table 12. The course cost estimate was derived from the CNET per capita course costing system.

TABLE 12. SUMMARY OF THE POTENTIAL ANNUAL SAVINGS MADE POSSIBLE BY THE USE OF CAITS AND ATTAINED BY REDUCING THE LENGTH OF THE AIRMAN APPRENTICE COURSE

Cost Per Course Hour	Throughput Per Year	Time Reduction Per Student	Cost Reduction Per Yr	
			Per Student	Total
$11.50	2,000	14.5 Hrs	$166.75	$333,500

The total life-cycle costs savings, in present value terms, are shown in table 13.

TABLE 13. SUMMARY OF LIFE-CYCLE SAVINGS WHICH ARE POTENTIALLY POSSIBLE WITH THE USE OF CAITS IN THE AIRMAN APPRENTICE COURSE (In Thousands)

	Year							
	1	2	3	4	5	6	7	Total
Annual Savings	$334	$334	$334	$334	$334	$334	$334	$2,338
Net Present Value								2,155
Net Present Cost								158
Difference								$1,997

The additional time made available by the use of CAITS could be used for instruction in the school or the course could, in fact, be shortened by nearly 2 days without reducing the time available for instruction. An administrative decision would be necessary to capture the additional time available. It is doubtful if a reduction in course length would allow all the potential savings to be captured in the short run but in the long run adjustments in the management and structure of the course could be made to realize most of these potential savings. The magnitude of the potential savings is such that there can be little doubt that the use of CAITS in the Airman Apprentice course leads to substantial improvements in efficiency.

One might question whether the remediation provided by the computer was as effective as the group posttest remediation. The findings from the previous section demonstrated that the final comprehensive test scores comparing computer remediated students and conventional posttest remediated students were not statistically significant. One can, therefore, conclude that the performance of the computer remediated student was no lower (or no higher) than the conventional remediated student even though the time spent in computer remediation was less than 10 percent of the time spent in the conventional review and remediation period. This time reduction certainly represents an improvement in training efficiency. No analysis was conducted to determine if either form of remediation significantly changes final comprehensive test scores.

The CAITS provides the capability to record student responses by content area and thereby provide instructors a record of the areas where individual student performance has demonstrated weaknesses. The CAITS also provides instructors an opportunity, and the necessary data, to focus their remedial efforts on the specific weakness exhibited by students. Summary results of student performance are also available, and these provide information on course content areas where the instructional program is weak or in need of revision.

Instructors and students are not adverse to the use of the computer, and there are recent indications that students prefer computer testing after they become familiar with the computer. Users of CAITS have not found it difficult to use in the operational environment. The pilot system is presently being used in the school by instructors and students who have had limited experience with this type of computer application.

Other anticipated benefits include an improvement in the capability to compile and report administrative data on students. With some relatively minor programming effort, the individual student performance data could be machine entered into a centralized data file from the student data disks. Since student response data is available for each test item, the summary data from the CAITS can be used to do item analysis and evaluate reliability of the tests. With expanded use of CAITS, it would be possible to establish a centralized test analysis capability where highly skilled personnel could be used for analysis of the validity and reliability of tests.

SECTION V

CONCLUSIONS AND RECOMMENDATIONS

This section contains conclusions regarding the effectiveness and efficiency of the CAITS and recommendations for the use of CAITS in Airman Apprentice and other Navy schools. The conclusions have been organized into those dealing with (1) effectiveness evaluation, (2) economic evaluation, and (3) management considerations.

The conclusions involve occasional reference to the treatment groups employed in this study. These groups are listed again to facilitate the presentation.

- Control Group--traditional paper and pencil testing with 1 hour allotted for testing and an additional hour allotted for full class review/remediation

- Experimental Group with Computer Remediation--Computer based-testing and computer-based remediation with remediation being presented only to students who have not satisfied criteria for specific content areas within test

- Experimental Group without Computer Remediation--computer-based testing with traditional full class review/remediation.

EFFECTIVENESS EVALUATION CONCLUSIONS

1. There were no significant differences in the comprehensive test scores of the experimental group with computer remediation, the experimental group without computer remediation (traditional review/remediation only), and the control group.

2. There was an improvement in the content area test scores for the experimental group with computer remediation immediately following remediation. Sixty-three percent of the remediations resulted in a passing score on the post remediation test. However, the relative contributions of remediation and/or retesting could not be directly assessed in this study. The effect of various forms of remediation can only be assessed through a controlled experiment designed for that specific purpose. There was no apparent long-term benefit to remediation based on comprehensive test content area scores.

3. Average testing time for computer-based testing was slightly less than 29 minutes (both experimental groups) plus approximately 5 additional minutes for remediation and administrative overhead for the experimental group with computer remediation. The additional time is not added to the experimental group without computer remediation. For noncomputer (traditional) testing, 1 hour is allotted for testing and 1 hour for review and remediation.

ECONOMIC EVALUATION CONCLUSIONS

1. A 15 student station CAITS used as a testing center for the Airman Apprentice course at Great Lakes has the potential for saving 14,500 student hours per year. Translating student hour savings into real cost savings or improvements in effectiveness will require that management reduce the length of the Airman Apprentice course or effectively utilize the saved student time.

2. The present value cost for a 7-year life cycle of the first CAITS was $94,022. The present value cost for a 7-year life cycle of a CAITS replication would be $54,097.

3. The CAITS offers nonquantifiable benefits in areas such as immediate student performance feedback, class level data collection which can be machine transmitted to various data bases for administrative or management purposes, capabilities for test item analysis, and individualized remediation.

4. Based on cost per course hour and time reduction realized with CAITS, a long run potential exists for savings worth approximately 2 million dollars during a 7-year system life cycle for Airman Apprentice training at Great Lakes. These potential savings are contingent upon the continued operation of the present CAITS, adding an additional 15 student station CAITS testing center, and managing the Airman Apprentice course to effectively utilize the saved time or reduce the course length.

MANAGEMENT CONSIDERATIONS

1. The CAITS project demonstrated the feasibility of using Program Development Center personnel for high technology development when personnel with specialized skills from other NAVEDTRACOM activities are available for support.

2. The collocation of the development activity with the using activity facilitated development and implementation of CAITS. This gave the using activity a sense of partnership in development which resulted in an efficient transition from development to school implementation.

3. Computer-based remediation serves to correct test performance deficiencies in two-thirds of the remediation cases for the short term. The remaining one-third of the remediation cases, which represents approximately three percent of all content area testing, must be instructor remediated. This indicates that either additional computer remediation may be required or that allowance should be made for the inclusion of instructor time to provide this remediation.

RECOMMENDATIONS

1. Expand the existing CAITS at Airman Apprentice School, Great Lakes, by adding a second 15 station testing center. This will provide the capacity to accomplish all Airman Apprentice testing by CAITS at Great Lakes and realize the projected savings discussed in section IV.

2. Evaluate the economic feasibility of implementing the CAITS for all apprentice testing at the three apprentice training locations.

3. Evaluate the feasibility of utilizing the CAITS concept for recruit testing at the three Recruit Training Commands.

APPENDIX A

CAITS TESTING STRATEGY AND SOFTWARE DEVELOPMENT ASSESSMENT

TAEG:MMZ
19 February 1981

From: Director, Training Analysis and Evaluation Group
To: Chief of Naval Education and Training (N-932)

Subj: Alternative means of Computer-Assisted/Interactive Testing (CAIT) Testing Strategy and Software Development

Ref: (a) CNET ltr Code 022 of 6 Jan 1981
(b) NAVEDTRAPRODEVCENDET, Great Lakes Proposal, "Computer Assisted/ Interactive Testing (CAIT) Strategy Proposal for Airman Apprentice 4.0 Week Expansion Program"

1. Reference (a) requested the TAEG to review reference (b) and examine alternative means of accomplishing the development of the testing strategy and software program. Findings, including statements of total time to completion and all costs, were to be submitted to CNET along with recommendations.

2. A meeting was held between members of the TAEG and NAVEDTRAPRODEVCENDET, Great Lakes, on 5 and 6 February 1981 to outline details of the testing strategy and to examine the capabilities of present equipment with regard to the implementation of the testing system.

3. Agreement was reached between TAEG and NAVEDTRAPRODEVCENDET, Great Lakes, on the minimum functional specifications to be met by the CAIT, including testing strategy, remediation strategy, management information requirements, and design constraints.

4. It was concluded that the CAIT proposal in reference (b), as modified during the discussions of 5 and 6 February, is not only feasible but also has potential for significant training efficiencies. However, the current hardware configuration cannot meet system design specifications. Additional equipment is required to fully implement the system.

5. It is recommended that a 32-station testing system be implemented with dual 16-station subsystems. This will insure adequate system reliability and backup capability. The additional hardware components necessary to complete the testing configuration will require \$24K of O&MN funding. These equipment costs remain the same regardless of the alternative chosen for software development.

6. Three alternatives have been identified for the development of the system. These are identified below along with their associated costs and development time.

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ALTERNATIVE	HARDWARE DEVELOPMENT	SOFTWARE DEVELOPMENT	CALENDAR MONTHS TO COMPLETION
1	IN HOUSE ($24K EQUIPMENT)	CONTRACT (DESIGN & PROGRAMMING $50K)	12
2	IN HOUSE ($24K EQUIPMENT)	IN HOUSE (DESIGN & PROGRAMMING BY IN HOUSE PERSONNEL)	18
3	IN HOUSE ($24K EQUIPMENT)	IN HOUSE (DESIGN BY IN HOUSE PERSONNEL CONTRACT PROGRAMMING $18K)	8

In addition, there may be a requirement for operating system modification by the equipment vendor ($10K).

7. It is recommended that alternative 3 be implemented. This alternative has a relatively short development time and minimal costs. In addition, it maintains the testing and system expertise in house. This expertise would be particularly valuable should a decision be made to expand the system to other sites. Although alternative 2 has the same desirable features of alternative 3, it is not recommended because the use of in house personnel will have negative impacts on the completion of other programs at NAVEDTRAPRODEVCENDET. Alternative 1 is not recommended because of its relatively high cost and because all system software expertise would reside with the contractor.

8. For all alternatives TAEG will:

a. Provide functional performance specifications

b. Provide hardware/software system design specifications

c. Conduct progress reviews and an operational test and evaluation of the complete system

d. Conduct an economic evaluation of the operational test system.

/s/

A. F. SMODE

Copy to:
CNET (Code 02, 022)
DIR NAVEDTRAPRODEVCENDET, GLAKES

APPENDIX B

CAITS FUNCTIONAL SPECIFICATION

FUNCTIONAL SPECIFICATIONS
COMPUTER AIDED INTERACTIVE TESTING SYSTEM
GREAT LAKES, ILLINOIS

The functional performance characteristics described in this specification are to be incorporated into the design of the Computer Aided Interactive Testing System (CAITS).

ADMINISTRATIVE SUBSYSTEM

1. Registration

a. Instructors will enroll students into the CAITS. As a minimum, enrollment information will include SSN, name, class, and other biographical/performance data normally maintained on student "hard cards."

b. The CAITS student record will provide for entries concerning:

(1) Setback

(2) Attrition

c. Only instructor and staff personnel will be authorized to change student record data.

d. The administrative subsystem will provide hard copy output to be used as class rosters for instruction.

e. Information contained in the administrative subsystem will be maintained in standard ASCII format to make it suitable for transfer to other NAVEDTRACOM management information systems.

2. Progress Reports

a. At the completion of each test, the system will provide a student status report containing three parts:

(1) (a) Alpha and SSN students who passed/w. score/subpart score.

(b) Alpha and SSN students who failed/w. score/subpart score.

(2) Alpha and SSN students who missed test for authorized/unauthorized reasons.

(3) Alpha and SSN students assigned off line remediation and assignments (content areas requiring remediation).

3. The administrative subsystem will provide, on demand, a report containing the alpha and SSN of students dropped in a particular time frame. It will also include the appropriate codes for separation reasons as applicable in the school. These data will be maintained on a class, quarterly, and/or annual basis.

4. The administrative subsystem, on demand, will provide a setback/advance report. This report will contain the number of students advanced/setback in a particular time frame. It will also provide the appropriate codes used by the school to report these actions to higher authority. These data will be maintained on a class, quarterly, and/or annual basis.

5. Student Performance Summary. The administrative system will report the performance score of individual students at any given time. This report will include grades, exams missed, and number of remediations by content area, and for the duration of system development and evaluation individual student records will be maintained in computer compatible archival form at IPDC DET, Great Lakes. It is recommended that consideration of long term storage of archival data be included in the Instructional Management Plan (IMP). Records will be maintained in the archives for 2 years to insure availability for longitudinal research and/or evaluation projects.

TESTING SUBSYSTEM

1. Testing Strategy

a. A test will be organized so as to evaluate each content area in an instructional unit. Test items will be keyed to specific content areas and learning objectives. The number of test items will vary with the number of learning objectives being tested. Generally, the maximum number of items shall be 50 and the minimum 10.

b. Test performance of each student will be immediately evaluated on-line against performance criteria established by the curriculum developer. This assessment will consist of evaluation of both individual item responses and patterns within content areas. For those items or content areas on which students fail to reach criterion levels, the testing strategy requires that remediation of either a specific or general nature be provided, based on remediation requirements established by the instructional developer.

c. Immediately following on-line remediation, students will be administered a second form of the test. This test is to be composed of a second form of all content areas previously remediated to include all critical items, as defined by the instructional developer.

d. Failure on a test following remediation (Test II) will require the student to be assigned remediation offline and/or to be referred to the instructor for further guidance. The instructor will be required to verify off-line remediation prior to administering a third test covering all content areas originally tested. Failure on this final examination in a topic area will require action in accordance with school policies in effect at that time.

2. Test Construction and Analysis

a. A pool of test items sufficient in size to permit construction of three alternative and parallel forms of each test. Items will employ a multiple choice response format. Question stems may be of any form which

permits objective responses. Centralized storage for a maximum of 3,000 items will be provided. Student stations will store one complete test with remediations.

b. All items will be keyed to specific learning objectives and content areas. Tests of an appropriate size for each of the instructional units will be constructed by the computer.

c. Item distractors are to be either partially or totally randomized for delivery and coded in such manner that all student responses can be returned to the original test format prior to randomization for delivery. Unless otherwise specified the default condition will be total randomization of responses.

d. During the development, test, and implementation of the CAITS, test authoring and analysis capability will reside at NETPDCDET, Great Lakes. Responsibility for test development and analysis may be transferred to the school subsequent to system development.

e. All tests (including parallel forms) will be maintained on a central computer fixed disk. This storage will include at maximum a total of 10 unique tests varying in length from 10 to 50 items (each having additional parallel forms) and associated remediation for each test.

3. Data Storage and Analysis

a. Each test to be administered shall be duplicated in its entirety from the central computer file onto a read only floppy disk. Each student is to receive a disk containing the appropriate test, associated remediation material, and a second form of the test. Each student terminal is to act in stand alone mode for each test. Software located in the student terminal will administer and evaluate test performance and assign necessary remediation. Following initial remediation, this stand alone system will administer the required second test materials. Students failing the second test will be assigned either to off-line remediation and/or to the instructor for further guidance.

b. The entire test battery shall be maintained under secure conditions at the schoolhouse in accordance with Test Control Officer policies.

c. Tests shall be transferred from fixed disk to individual floppy disk for distribution to each student. A complete inventory of all tests on floppy disks will be maintained under secure conditions at the schoolhouse. Floppy disks available to student shall be "read only."

d. All student response data will be stored on floppy disk memory at the student station until such time as the student has completed the testing session; at that time all response data will be transferred to the student's permanent record in the control computer.

e. Student data to be collected and transferred to the central computer shall include:

(1) distractor selected on each item by each student
(2) correct or incorrect grade or response on each item
(3) time required to complete item
(4) number of items and content areas remediated per test
(5) number of remediations per content area and per test
(6) final grade on test
(7) pass/fail
(8) setback/attrite
(9) test form identifying information.

f. The system will also report the student start and stop times on the test and the date. These will be recorded by module, content area, or entire course and will be summarized on an individual student and class basis. Times taken for individual items by students will be monitored and recorded and when a criterion level established by curriculum developers has been reached, the system will set a warning flag. The flag will be indicated at the instructor station console and be used to monitor potential performance problems.

g. The system will limit each multiple choice item and/or graphics item to one page (video display screen).

4. NETPDCDET, Great Lakes, will have initial responsibility of the maintenance of an overall and complete response history of each item in the curriculum. Subsequent to the development of test and implementation of the CAITS, this responsibility will be assumed by the school. Response histories will be updated periodically; e.g., monthly, consistent with the overall system design for maintenance of response information. These items will be retained in an item bank (archive) and periodically reexamined for reliability and validity. The item bank will be so constructed as to maintain items by content area and learning objectives.

5. An off-line item analysis capability will be maintained at NETPDCDET. These analyses will consist of item difficulty, item discriminability, reliability, and validity (if data are available). Periodic revision of tests shall be undertaken based on these analyses. These evaluations shall be undertaken at any time an item analysis suggests a revision may be required, but at a minimum, revisions shall be undertaken every 2 years. Item analyses by class shall be made available on request.

6. Periodically; e.g., monthly or quarterly, response information will be stripped from the files of the central computer and be transmitted to the Evaluation Branch of the NETPDCDET. These data will be merged with those resident in the item data bank.

TEST DELIVERY SYSTEM

1. The system shall be equipped to accommodate an average class size of 32 students at one sitting. Each student testing station is to be provided a microcomputer with video display.

2. All tests will also be maintained in paper and pencil format to serve as backup should the primary computer based system fail. These paper versions of the test are to be maintained in a secured location under control of the school. Any revisions to the computer based test will be reflected in the manual testing system as necessary.

3. The system will provide the capability for on-line monitoring of student station progress at the option of the instructor. This capability is not to act to simply repeat current information on a student station display but is to permit a selective search of student test record.

4. All files in the central computer shall employ a file protect feature to guard against accidental erasure or overwrite; e.g., power outages. A contingency plan will be specified prior to system installation for booting any backup files.

5. The test delivery system shall be designed to allow for future expansion of capabilities in CAI and testing and to permit fully automatic interactive testing under the control of a central computer without intervening manual transfer of information to individual test sites. The system will also allow for the eventuality of exporting instruction/testing to remote sites. Student stations should be designed to permit stand-alone operation and/or permit integration into local area instructional networks.

APPENDIX C

CAITS DESIGN SPECIFICATION

Technical Report 152

COMPUTER AIDED INTERACTIVE TESTING SYSTEM

SYSTEM DESIGN SPECIFICATION NO. 1170-DS

June 15, 1981

Prepared by C. L. Morris

Training Analysis and Evaluation Group

This System Design Specification has been prepared as an in-house Instructional Program Development control document. It should not be considered for use as a procurement specification without proper formatting and the inclusion of additional specification information.

COMPUTER AIDED INTERACTIVE TESTING SYSTEM

SYSTEM DESIGN SPECIFICATION

1.0 SCOPE

This specification covers the hardware and software requirements for the design, development, and test of the Computer Aided Interactive Testing System (CAITS). The CAIT System will conform to functional specifications, No 1170-FS of June 1981, and will satisfy training requirements developed under NAVEDTRA 106A and NAVEDTRA 110. In the event of conflict between CAITS requirements and training system requirements, training system requirements will take precedence.

The CAIT System specified herein is intended to satisfy a portion of the testing requirement for the Airman Apprentice Training Program at RTC, Great Lakes. Additionally, it will have general applicability to other Navy training programs. It will function as an integrated testing system as described in this specification for group testing application and will also function as a single station, stand-alone system with a combined text and computer graphic capability. These features allow a range of computer based instructional applications including instructional delivery and instructional management. This enhanced capability, if desired, can be provided by developing additional applications software. It will also be possible to expand data storage and to provide special purpose input-output capabilities by adding plug compatible hardware. With this flexibility it is envisioned that other training requirements can be satisfied with incremental additions of software and hardware.

2.0 SYSTEM REQUIREMENTS

The CAITS will utilize commerically available computer hardware subsystem components wherever possible. Processors, disk storage units, printers, display/keyboard units, controllers and interface logic should be selected on the basis of performance, intra-system compatibility, supportability and cost. In addition, the hardware portion of the CAITS will support necessary system features such as system diagnostics and general system utilities.

The development software for the CAITS will consist of vendor supplied operating systems, interpreters, compilers, assemblers, editors, file management systems and general utilities. The operational software will consist of the applications programs for the instructor station and the student stations together with the operating system, interpreter and monitor software/firmware. The hardware, software, and testing requirements for the CAIT System are considered to be deliverables and are addressed in paragraphs 2.1, 2.2, and 3.0 of this specification.

2.1 HARDWARE REQUIREMENTS

The hardware configuration for the CAIT System is shown in figure (1). As shown, the system consists of a two Microcomputer Instructor Station, 16 single microcomputer student stations and interface logic. Two 16 station systems as shown in figure (1) will constitute a 32 station testing system.

2.1.1 INSTRUCTOR STATION

An Instructor Station will consist of an Ohio Scientific C3-D microcomputer system with parallel interface to a Bell and Howell 3048D microcomputer system.

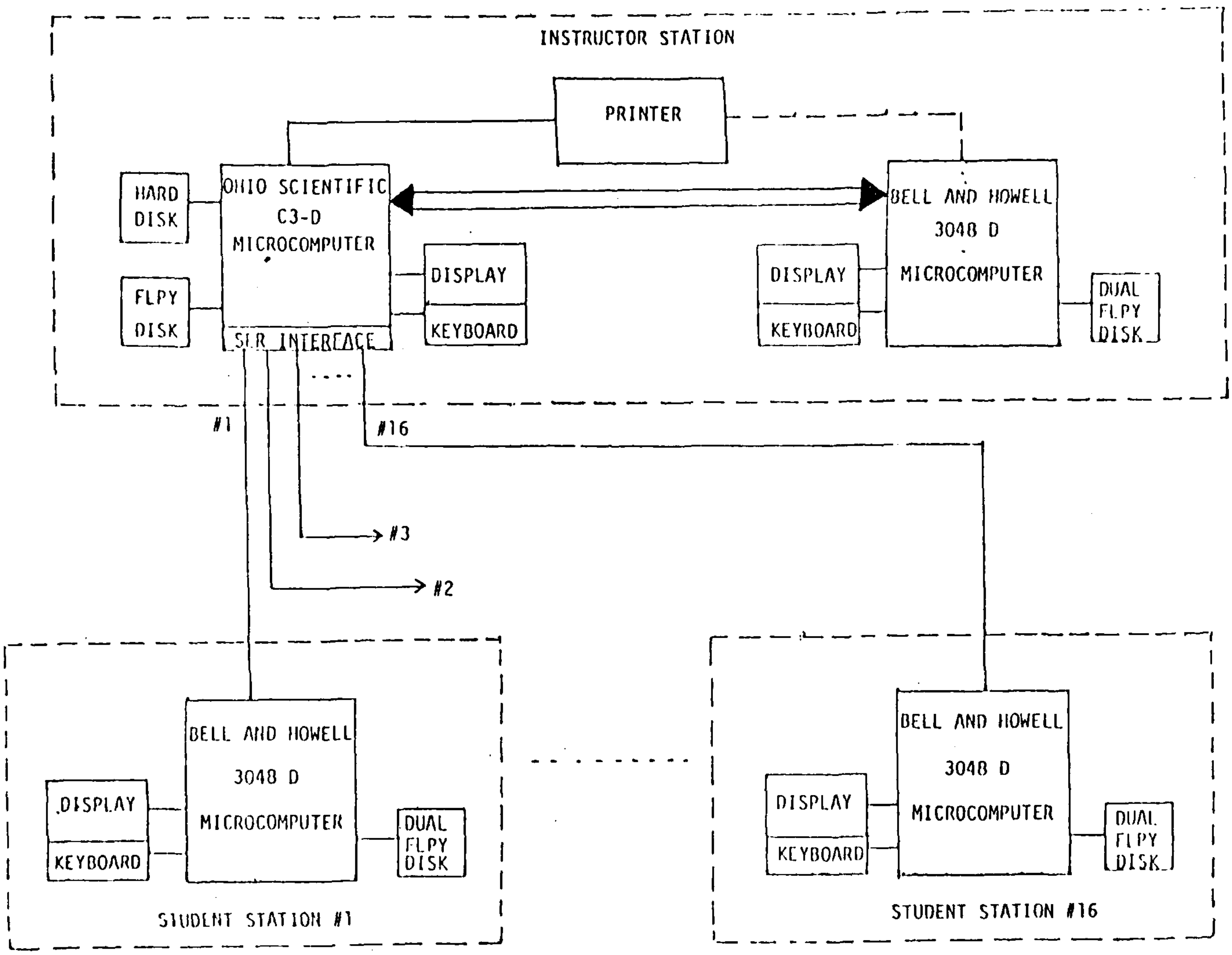

Figure 1. CAITS Hardware Configuration

Each of these computers operate under vendor supplied operating systems and special purpose applications software. Program compatibility between computers will not be required since each processor will provide dedicated computer functions. Data interchange will be in accordance with predefined data formats and communications protocol. Communications control will follow a master-slave philosophy.

2.1.1.1 INSTRUCTOR STATION DISK STORAGE

The Ohio Scientific C3-D Microcomputer System includes an integral 10 megabyte hard disk unit and an 8 inch floppy disk unit. The hard disk will contain all of the applications programs, student records, test masters and control Programs. The floppy disk will be used for program transport, hard disk back-up and archival storage.

The Instructor Station Bell and Howell dual floppy disk unit will be used to generate student station floppies for student testing. The test item selection and sequencing will be under test author control and will be in accordance with the CAIT System functional specification.

2.1.1.2 KEYBOARD DISPLAY

The instructor station will include two keyboard-display units, one for the Ohio Scientific microcomputer and one for the Bell and Howell microcomputer. Although a single keyboard display could be utilized for both microcomputers, only one computer at a time would be operational. Although this would not normally affect system operation, there will be occasions when it is desirable to make floppy disk copies at the Bell and Howell station while test management is taking place at the Ohio Scientific station.

2.1.1.3 PRINTER

A printer is required at the Instructor Station to provide hard copy output in many functional areas. Some specific examples are student progress reports, class testing schedules, evaluation reports, test masters, system diagnostic records and test center management information reports. Although the printer will normally be used as an Ohio scientific microprocessor peripheral, it should be capable of functioning as a Bell and Howell microprocessor peripheral without special adaptation. Because this printer will be used in the testing center, selection factors should include low noise, high reliability, medium print speed, good print quality and graphics reproduction capability. A high quality, high dot density matrix impact printer appears to be a reasonable choice but thermal, ink jet and daisy wheel options should be considered in the selection process.

2.1.2 STUDENT STATION

Each student station will consist of a Bell and Howell 3048D microcomputer, a monitor for display and a Bell and Howell dual floppy disk drive. The keyboard portion of the keyboard-display capability is an integral part of the micro-computer system and will function as the student test response input device.

Each student station microcomputer communicates with the host Ohio Scientific computer via a serial RS-232C line. This communications link provides for information interchange relating to student identification, test item response, student station status and test management/control. All testing data (test items, remediations and graphics) will be contained on floppy disk. Distribution control for the test floppies will be maintained by the instructor/proctor.

2.1.2.1 STUDENT STATION DISK STORAGE

The Bell and Howell dual floppy disk drives at each student station will be utilized during both integrated system operation and stand-alone operation. The number one drive will contain the system disk and will provide temporary storage for test item responses. During integrated system operation these responses will be transmitted to the central instructor station as required. During stand-alone operation the responses will be stored on floppy disk until action is taken by proctor to transport the disc to a data reduction location. The number two drive will contain the test floppy. This floppy will be write protected and software read protected to maintain test security. The data format on both floppies will be in accordance with Bell and Howell specifications and will not be compatible with the Ohio Scientific floppy format or the Ohio Scientific disk operating system. It will, however, be fully compatible with the instructor station Bell and Howell microcomputer disk operating system. Computer to computer data interchange between Ohio Scientific and Bell and Howell will provide the necessary link to interchange disk data controlled by different disk operating systems.

2.1.3 INTERFACE AND COMMUNICATIONS

The hardware interface between microprocessor and standard peripherals (keyboard-display, printer, disk drive) will be standard vendor items for both the Ohio Scientific and Bell and Howell microprocessors. The driver software will also be standard for each vendor's software package with the possible exception of motherboard slot placement coding. This standard hardware-standard software approach to system design and development should be followed wherever possible in the interest of reducing system design complexity. It will also decrease risk and increase the probability of meeting design and development schedules.

The standard equipment approach cannot be followed fully in the case of interface between microprocessors of different manufacturers such as the Ohio Scientific and Bell and Howell in this system. For this case (instructor station to student station transfer) the serial interface will be standard RS-232C at the highest baud rate possible within the design limits of the vendor supplied hardware and software. Standard serial interface boards with minor modification should allow for 4800 baud. This option should be investigated during the design phase. Serial interface will be the standard communications link between instructor station and student stations. It will also allow for future modem linking for remote operation.

Although the hardware interface and communications protocol are fully defined for the computers to be used, the software system is not defined.

Information transfer can take place in many forms (Text, Basic Language Statements, Binary, Block Data Structure) and the form of data formatting for data interchange should be considered carefully during the design phase. This information transfer consideration must also include computer graphic information which is handled and formatted differently for each vendors microprocessor. Binary block (packet) transfer is suggested for this application.

The two microcomputers at the instructor station are also of different manufacture and must communicate at high data rates to provide flexibility in utilizing hard disk storage from the Bell and Howell work station. A standard parallel interface should be utilized for this computer to computer application. Special software will be required to provide the necessary data handling between computers. Terminal emulation is the preferred design approach since operating system, monitor and driver modification should not be considered. Assembly language subroutines will provide special features where required.

2.2 SOFTWARE REQUIREMENTS

The software development effort for the CAITS will consist of designing and developing applications programs to satisfy the Functional/Performance Specification Requirements. The documentation requirements for the CAIT System will be limited to the Program Performance Specification, Interface Design Specification, Program Design Specification, Data Base Design Document, Program Description Document, and Users Manual. The System Test Procedure and Report will be addressed separately in Section 3.0, Testing Requirements. A top down design approach will be followed which will define programs and program modules on the basis of functional performance relating to the system specification. The top down structure shall support functional modularity for ease of coding, system integration and subsequent program changes.

The functional requirements for the CAIT System are delineated in the CAITS Functional Specification No. 1170-FS of 1 June 1981. This specification constitutes the functional baseline from which the Program Performance Specification will be developed. The Program Performance Specification, when approved, will become the master design and configuration control document for CAITS program development.

2.2.1 PROGRAM PERFORMANCE SPECIFICATION

The Program Performance Specification shall describe the operational and functional requirements necessary to design, test and maintain the CAITS programs. It will provide detailed descriptions of program performance and the relationship of program functions to system functional performance requirements. The Program Performance Specification (PPS) will be used as a controlling document for the design and test of programs developed for the CAIT System. Data Item Description, DI-E-2136/MOD, Specification, Program Performance (PPS) of 2 July 1979 will be used for guidance in the development of the CAITS PPS.

2.2.2 INTERFACE DESIGN SPECIFICATION

The Interface Design Specification (IDS) will define the inter/intra processor interfaces in the CAIT System. It should provide a description of the

hardware and software interface logic, communications conventions, data types/formats and data communication rates. Interface Design Specification (IDS) Data Item Description DI-E-2135/MOD will be used for general guidance only. The CAITS IDS will provide fully descriptive information for all CAITS Interface (program and physical). This document must be maintained under configuration control since it will be a key document during system test and follow-on life cycle support.

2.2.3 PROGRAM DESIGN SPECIFICATION

The Program Design Specification (PDS) will follow the guidelines established in Data Item Description DI-E-2138/MOD. A work breakdown structure will not be required for the CAIT System. However, functional allocation should be identifiable and traceable from the functional performance specification to programming module flow chart/diagram/model. The program Design Specification will be the software design document for each program module and as such should provide the programmer with fully descriptive information for program coding.

2.2.4 DATA BASE DESIGN DOCUMENT

The Data Base Design Document (DBDD) will provide a complete and detailed description of all common data items (variables, strings, arrays, constants, booleans) to be used by more than one program module. This document will be of great importance in the design philosophy to be followed when using the Basic Interpretive Language. Modularization of programs will require data initialization and data reset inhibit features beyond those normally available with the interpreter firmware. Special programming provisions will be necessary for handling common data items. Data Item Description DI-S-2140/MOD should be followed during the preparation of this document.

2.2.5 PROGRAM DESCRIPTION DOCUMENT

The Program Description Document (PDD) shall provide complete technical descriptions of CAIT System module functions, structures, operational constraints, source and object listings, diagrammatic/narrative flows and data base organization. Data Item Description DI-S-2139/MOD will be used as a guideline during the development of this document.

2.2.6 USERS MANUAL

The Users Manual will provide an operational description of the CAIT System. It will also provide detailed procedures for all operating modes (test delivery, test authoring, report generation, evaluation). The procedural information will be clearly presented in user (non-programmer) language and will be modularly formatted. This manual should contain all of the information required for system operation without referring to other documentation since it will be the only manual available during normal operation.

3.0 TESTING REQUIREMENTS

All hardware, software, and system tests will be conducted in accordance with approved test procedures. Hardware testing will consist of diagnostic

testing, mechanical inspection and limited reliability testing. Software testing will consist of module testing and integration testing. System tests will demonstrate that functional performance requirements as delineated in the CAITS functional performance specification have been satisfied.

3.1 SYSTEM TEST PROCEDURE

The System Test Procedure for the CAITS will ensure that:

a. The system is tested in the operational environment under high stress conditions

b. All operational modes are tested

c. Recovery is possible without reinitialization for user generated faults

d. Student testing time is not constrained by computer

e. Data communications standards are satisfied

f. Modular testing of software is possible

g. All System Performance Specification requirements are satisfied

h. All System Design Specification requirements are satisfied

i. Documentation reflects the system design and configuration.

The test procedures will be prepared by the design and development group and will be submitted for approval 60 days prior to formal testing. They will identify the specification requirement relating to each test sequence and will clearly state the test criteria.

3.2 SYSTEM TEST REPORT

The System Test Report will follow the form of the System Test Procedures and will provide a display of test results. The criteria will be specified for each test sequence and the test results will be recorded in a form which will allow for ease of comparison to criteria. The test results will be documented in report format and will be combined with other system assessment information by the Training Analysis and Evaluation Group. The System Test Report will then be published for distribution as directed by the CNET Assistant Chief of Staff for Training System Management.

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